Spreading Non-natural Concepts: The Role of Intuitive Conceptual Structures in Memory and Transmission of Cultural Materials*

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ABSTRACT

The four experiments presented support Boyer's theory that counterintuitive concepts have transmission advantages that account for the commonness and ease of communicating many non-natural cultural concepts. In Experiment 1, 48 American college students recalled expectation-violating items from culturally unfamiliar folk stories better than more mundane items in the stories. In Experiment 2, 52 American college students in a modified serial reproduction task transmitted expectation-violating items in a written narrative more successfully than bizarre or common items. In Experiments 3 and 4, these findings were replicated with orally presented and transmitted stimuli, and found to persist even after three months. To sum, concepts with single expectation-violating features were more successfully transmitted than concepts that were entirely congruent with category-level expectations, even if they were highly unusual or bizarre. This transmission advantage for counterintuitive concepts may explain, in part, why such concepts are so prevalent across cultures and so readily spread.

Around a large citrus ranch in California, the locals all know about the Chivo Man who roams the "haunted dairy." Presumed by some to have been invented a generation ago by a mother trying to keep her children away from crumbling buildings, the story of the elusive and dangerous part-goat Chivo Man is now part of local cultural knowledge and regarded by many as true. Around the world and throughout the centuries people have shared stories and tales about animals that talk, artifacts that have feelings, and people with superhuman powers. These non-natural concepts spread with ease within and between cultures. Unlike natural concepts such as "water" and "food" that have definite and repeatedly verified real-world instantiations, these less mundane cultural concepts typically lack regular reinforcement through experience. Rarely does anyone actually report an encounter with the Chivo Man. Why then do concepts such as these occur across cultures and spread so well?

One way to account for the prevalence of types of concepts is how well they are remembered and transmitted (Boyer 1994; Sperber 1996). For a concept to become a part of a cultural system, somehow it must be represented in individual minds and passed on or transmitted. Sperber has even argued that "Culture is the precipitate of cognition and communication in a human population" (p. 97), and proposed an epidemiological program in the study of cultural representations: "To explain culture, then, is to explain what and how some ideas happen to be contagious" (p. 1). All else being equal, a concept that is easily remembered, with rich conceptual structure grounding it, will be transmitted more successfully and thus be more common than concepts that are difficult to remember or represent. To explain cross-cultural regularities or how a new concept could spread within and between cultures, what is needed is a set of conceptual mechanisms that is pan-cultural: essentially inevitable given innately specified cognitive biases plus ordinary interaction with the world in any cultural setting.

The two most prevalently discussed classes of conceptual structures are schemas and scripts, both of which are sets of culturally informed expectations used to interpret and remember stimuli that have been built up over past experiences (Bartlett 1932; Brewer & Nakamura 1984; Rubin 1995; Schank & Abelson 1977). Both facilitate efficient communication by allowing speakers of a common culture or set of relevant experiences

to make assumptions about what others already know. Because schemas and scripts are used to fill in ambiguous or missing information, they often serve a conservative effect in the transmission of ideas: unless stated otherwise, ordinary properties, events, or relations are assumed (Rubin 1995; Rumelhart 1977; Thorndyke 1977; van Dijk & Kintsch 1978). Additionally, in some contexts, concepts or features of an account that do not fit with the anticipated script or schema are difficult to integrate and thus remember accurately (Harris, Schoen & Hensley 1992). Using the wrong schema or script to interpret and encode a narrative or situation has also been shown to cause distortions or omissions in what is recalled (Bransford & McCarrell 1974).

In some tasks (e.g., when using recognition measures instead of recall, or after very short delays), script inconsistent information is frequently remembered better than elements that meet the expectations for that scenario (Gaesser, Woll, Kowalski & Smith 1980). However, the inconsistent items in these previous studies disrupted the script structure or were irrelevant, rather than integrated into a structure such as a narrative as occurs in real folk tales. Whereas research on schemas emphasizes their typically conservative function in the transmission of cultural materials, some memory research using within-subject designs also demonstrates that, much like perceptually distinctive stimuli are recalled better than non-distinctive stimuli, semantically or conceptually incongruous material is recalled more than surrounding mundane material (Schmidt 1991; Waddill & McDaniel 1998; Imai & Richman 1991).

Although research on schemas and scripts suggests the possibility that incongruent concepts may be better remembered thus contributing to their transmission, these conceptual structures are culturally variable to a large extent and will not provide an explanation for cross-culturally prevalent classes of concepts. The best developed account of how such conceptual systems might help explain cultural systems and religious systems in particular is Boyer's (1994) treatment of "counterintuitive" concepts. Drawing heavily on the work of developmental and cognitive psychologists studying concepts, conceptual structure, and ontologies, Boyer's theory contends that for any category, such as animal or artifact, people regardless of culture, hold a host of intuitive assumptions about its member's properties. These assumptions, in turn, are the consequence

of a host of intuitive theories (Keil 1989; Gelman & Markman 1986). For example, because a cat is an animal, our intuitive or folk biology applies to cats and we tacitly assume that cats have nutritional needs and will eventually die. These are two properties of "cat" that need not be explicitly represented or communicated. Further, we expect cats to move purposely to fulfill their needs. These intuitive expectations provide the basic structure to concepts.

What distinguishes many "religious" and some cultural concepts from other concepts is that religious concepts typically possess a small number of features that violate category-level expectations (Barrett 2000; Boyer 1994, 1995, 2000). For example, a person who can pass through solid objects (a ghost) is counterintuitive, satisfying the bulk of intuitive expectations for the category of intentional agents but possessing one category violation concerning physical properties. Concepts of these sorts are common in religious systems and folk tales from around the world. As has been argued elsewhere (Sperber 1994), it is these counterintuitive properties that make religious concepts salient. Increased salience, in turn, enhances the likelihood that the concept will be remembered and passed on.[1]

Expectation-incongruent or "counterintuitive" does not necessarily mean unusual, surprising, or difficult to think about. A theologian may find it very easy and common to reason about God's omniscience but that does not mean that an intentional agent who knows everything does not violate expectations at the category level. Counterintuitive in this technical sense means that a member of a particular category (e.g., animal, artifact) possesses a feature that violates intuitive expectations that are regularly acquired by children in any cultural setting for a given category.

Previous research on conceptual structures and memory dynamics is encouraging, but was not intended to test if counterintuitive concepts

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[1]The claim that intuitive ontology-violating properties of concepts make them salient and more likely to be remembered and transmitted should not be confused with the controversial claim that concepts that conjure bizarre imagery are more likely to be remembered (Einstein, McDaniel & Lackey 1989). A concept may be bizarre or unusual (e.g., a 100-pound beetle) and not violate any intuitive assumptions. Likewise, a concept may clearly violate intuitive assumptions and not necessarily evoke bizarre imagery (e.g., a mountain with no mass). The two hypotheses are orthogonal. Boyer's claim is that, all else being equal, expectation-incongruent concepts will be better remembered and transmitted than mundane or merely bizarre concepts.

have a mnemonic advantage (see Boyer & Ramble, in press, as a notable exception). The following four experiments begin to address the hypothesis that, all else being equal, concepts that have a property that violates intuitive assumptions for that thing's category membership will be better remembered and *transmitted* than other concepts.

Experiment 1

To test the hypothesis that expectation-incongruent concepts are more memorable than standard concepts, an experiment was constructed and results analyzed along the lines of Bartlett's serial reproduction studies. Using an American Indian story, "The War of the Ghosts" (1932), Bartlett had subjects read the story and then retell the tale in writing. These retellings were then read and retold by other subjects. Over several generations of retellings, Bartlett reported that culturally unfamiliar concepts became distorted to better fit cultural schema, while other non-schematic concepts were forgotten. Most strikingly, Bartlett observed that although the story's title suggests that the story features ghosts, the concept of ghost had been eliminated over the course of ten retellings. In trying to capture both omissions and distortions in a single explanation, Bartlett argued that culturally unfamiliar, non-schematic concepts such as ghosts and canoes are more difficult to represent and thus less likely to be remembered and transmitted faithfully. In addition to Bartlett's study, other cross-cultural studies have repeatedly demonstrated that stories from one's own cultural setting are better remembered and retold than stories from other cultures (e.g., Kintsch & Greene 1978; Steffensen & Colker 1992), and that the tendency to distort a story from another culture to fit one's own cultural knowledge increases with length of delay before recall (Harris, Schoen & Hensley 1992).

Despite this supporting research, if expectation-violating concepts are more salient than standard ones and thus have a transmission advantage as Boyer's theory suggests, then Bartlett's finding is problematic. Several methodological issues make his conclusion suspect. In his explanation of his findings, Bartlett fails to distinguish between omissions and distortions of concepts, leaving unanswered the question of why the concept of 'canoe' was remembered while that of 'ghost' was forgotten. Furthermore, Bartlett relied on only one story whose idiosyncrasies might have contributed to the

eventual omission of the "supernatural" features of the story. In addition, Bartlett's experiment was set up in such a way that the recall rate of the culturally exotic, expectation-violating items was not compared to that of culturally familiar items, so the rate of omission might not be above chance.

Experiment 1 involves a reexamination of Bartlett's findings with similar stimuli, American Indian folktales. Since American Indian stories are generally unfamiliar to non-American Indian North American university students, and historic American Indian culture is likewise unfamiliar, the use of such stories should limit the effect of culture-based schema on memory, allowing non-cultural ontological assumptions to surface. Native American stories are also appropriate to this study since they are the products of oral tradition involving many generations of retellings and are thus representative of most simple cultural narratives around the world.

Method

Participants. Participants were 48 university students, 21 female, ranging in age from 18 years to 21 years, with a mean age of 18.7 years. None of the participants were American Indian. Half of the participants read and retold one set of three stories, and half the other three stories.

Materials and Procedure. In hopes of avoiding the problem of using an unrepresentative story, ten stories of 500 words or less were randomly selected from a collection of 166 American Indian stories (Erodes & Ortiz 1984). To maximize thematic and stylistic differences in the sample, one story from each of the ten thematic divisions of the collection (e.g., creation stories, trickster stories, end times, etc.) was randomly selected. Of these ten stories, four did not contain any counterintuitive characters or events and so were not used in the experiment. The remaining six stories were randomly ordered and divided into groups of three. Six stories were used rather than one to help control for any idiosyncrasies of any particular story.

To illustrate, one story told of two children waiting by a fire while their grandmother climbed to the top of a mountain to fetch a special plant. The grandmother diligently struggles to the top only to roll down the mountain to her death when the plant pulls out of the ground in her grasp. The grandmother's bones then walk home singing. The children hear the singing and know that their grandmother has been transformed.

Thus, they run inside their dwelling, covering the opening. The children then transform themselves, one turning into a burning stick and one into a blue stone.

Participants in the experiment were read one group of three stories all the way through, one time slowly. After participants completed an unrelated questionnaire requiring approximately 15 minutes, the experimenter instructed participants to retell the stories in the same order they had heard them, recording the retelling in writing on lined notebook paper.

We hypothesized that concepts or events with counterintuitive features would be remembered and retold more accurately than concepts with only common features.

Results and Discussion

The stories participants generated were coded simply for recall of expectation-violating concepts and ordinary concepts. For example, in the story about the transformed grandmother, there are two basic expectation-violating concepts: the events of the grandmother's dead bones coming back to life, and of the grandchildren turning themselves into a blue stone and a stick burning at one end. The ordinary concepts in the story were a mountain, a plant, rocks, a house, and a mine (blanket). Expectation-violating concepts were relatively easy to identify because they are almost always a single event or property. However, ordinary concepts can be demarcated in many ways. To keep from inflating the number of ordinary concepts (and thereby increase the chance of them being forgotten), any reference to an explicitly mentioned object, person, or activity was coded as remembering the general concept. For example, in the transformed grandmother story, the plant that the grandmother climbs the mountain to retrieve is described as "a plant which the Indians use for food," participants were not required to recall "Indians" and "food" in addition to the concept "plant"; the mention of "plant" alone was sufficient.[2]

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[2]Since coders would have to first agree on what constituted a bit of information from the story, then which bits were remembered, and finally which bits were counterintuitive, only a single coder was used. Consequently, the results are most helpful when combined with Experiments 2, 3 and 4.

Averaging across both sets of stories, the 20 counterintuitive concepts (8 in one set and 12 in the other) were recalled 60.4 percent of the time ($SD = 20.7$ percent), whereas the 46 control concepts (18 in one set and 28 in the other) were recalled 43.3 percent of the time ($SD = 18.1$ percent). This difference was significant, $t(23) = 8.08$, $p < .001$.

As with Bartlett's studies, the retellings demonstrated several types of changes from the original stories. In his studies of serial reproduction, Bartlett noted three main classifications of change: omission, in which concepts are completely forgotten; rationalization, in which participants forge explanatory links and provide reasons for occurrences; and transformation of detail, in which unfamiliar concepts are transformed into more familiar concepts. All three types of change were evident in the retellings.

Transformation of detail occurred with culturally unfamiliar concepts in many of the retellings: a buffalo chip was remembered as a cow chip and a wood chip, the Salt Lake was remembered as the Great Lakes, and a man fishing from the shore was remembered as a man fishing from a boat. Some of the changes involved the simplification of a more complex concept rather than a complete transformation of detail: specific listings of plants were remembered as crops and plants, the pinon tree remembered as just a tree, and the old man's decree that if the wood chip floats people will die and after four days come back to life was remembered simply as if it floats then people will live forever.

Rationalization was exhibited in a number of participant's recollections of the stories. For example, in the story of the "Greedy Father," the wife and children turn into a bear lily, a hazel bush, and a pine tree and are now said to "line up in front of rich people, baskets in the deerskin dance" (p. 321, Erodes & Ortiz 1984). One participant retold this section of the story in a more rational, cohesive way, explaining that "trees and bushes are used to make baskets." Another participant demonstrated rationalization by interpreting the story, "Woman Chooses Death," as "the Garden of Eden with a bit of a twist." In retellings of the story, "The Transformed Grandmother," two participants rationalized the part of the story in which the grandmother "pulled too hard, and away she rolled down the mountainside," by inferring that she fell because "a rock slipped" or "she lost her balance."

A small number of concepts suffered omission in most of the retellings. Proper names were often omitted, and sometimes distorted: the town of Cochiti was remembered as a pueblo called Chiripaw, the pinon tree remembered as chimperon tree and perapah tree. Contrary to Bartlett's findings conclusions, omissions in Experiment 1 mainly involved common concepts. Moreover, this study revealed no evidence that counterintuitives were omitted more often than other concepts. If anything, counterintuitive concepts were remembered better than other concepts.[3]

Although the rate of successful transmission in this experiment is suggestive, the design prohibits strong conclusions. Since the narrative format used did not allow for control of the importance, frequency, and development of concepts in the story, any number of factors might account for the results. In addition, the stories used were traditional tales that had been retold countless times and so the printed editions are likely the product of cognitive selective pressures that might have already tailored the stories to be maximally transmittable.

Despite the possible interference of factors due to design, this experiment challenges the assumption that culturally unfamiliar and expectation-violating concepts always present transmission difficulties. At least in the context of these stories representative of actual folk tales, the concepts which violated intuitive assumptions were remembered and retold better than more common concepts that concur with assumptions, setting the stage for more controlled studies.

Experiment 2

To retest the suggestion that a concept with a limited number of properties that violate categorical expectations might be remembered and transmitted more faithfully than a concept which meets expectations, a story was constructed that allowed for a controlled number of both concepts with expectation-violating properties and concepts with mundane, control properties. The story described an inter-galactic ambassador's visit to a

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[3]Contrary to the overall results, one expectation-violating concept, that of the magic crystal in the story of the Salt Woman, was forgotten more than the other expectation-violating concepts in that story and in the other stories (only two subjects recalled the crystal at all and only one remembered that it was magic) and the omission was not straightforward, but involved a transfer of magic power from the crystal to Salt Woman.

museum on another world (see Appendix A). This museum had 18 exhibits: six that illustrated various types of physical objects, six that illustrated various types of living things, and six that illustrated various types of intentional agents. As in Bartlett's serial reproduction, the first "generation" of participants were asked to read the story and then retell it from memory. The second generation read those retellings and retold them. The measure of central interest was how well the 18 exhibits were remembered and transmitted from generation to generation.

Method

The experimental manipulation was the version of the 18 exhibits with which participants were presented. Each exhibit had ontological information (living thing, physical object, or intentional agent), plus a sentence description of a property. These properties were one of three types: expectation-violating items possessed a feature that violates intuitive assumptions for the object's category membership (e.g., a living thing that never dies violates assumptions about all living things); bizarre items possessed a highly unusual feature that violates no category-level assumptions but may violate basic-level regularities (e.g., a living thing that weighs 5000 kilograms may be unusual for a dog, but weighing 5000 kilograms does not violate assumptions about living things in general); and common items possessed an ordinary feature for their category membership (e.g., a living thing that requires nutrients to survive). Table 1 lists examples from the story used.[4]

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[4]To insure that the counterintuitive levels of each item were not easier to vividly imagine, thus potentially giving them a mnemonic advantage, an independent group of 14 participants (9 female; mean age, 20.8) rated each of the items "how easy it is for you to form a vivid mental image of them" on a seven-point scale with a low score representing ease. Counterintuitive versions were significantly rated as more difficult to imagine ($M = 5.01$, $SD = 1.08$) than either the bizarre items ($M = 3.69$, $SD = .82$), or the common items ($M = 2.19$, $SD = 1.11$), and so if anything there would be a bias against the counterintuitives. The same precaution was taken for the stimuli used in Experiments 3 and 4, with a sample of 15 adults (9 female; mean age, 20.7 years). There was no evidence that counterintuitive items ($M = 3.99$, $SD = 1.04$) were easier to create a vivid image of than the bizarre items ($M = 4.37$, $SD = 1.06$), $t(14) = 1.15$, $p = .267$. However, counterintuitive items were significantly more difficult to imagine than common items, $M = 2.17$, $SD = 1.38$, $t(14) = 3.51$, $p = .003$.

Table 1

Selected items from Experiment 2 representing all three item types and all three levels

Intentional Agent

Counterintuitive — "a being that can see of hear things no matter where they are. For example, it could make out the letters on a page in a book hundreds of miles away and the line of sight is completely obstructed."

Bizarre — "a being that can see or hear things that are far away. For example, it could make out the letters on a page in a book if it is as much as 50 feet away, provided the line of sight is not obstructed."

Common — "a being that can see or hear things that are not too far away. For example, it could make out the letters on a page in a book if it is no more than eight feet away, provided the line of sight is not obstructed."

Living Thing

Counterintuitive — "a species that will never die of natural causes and cannot be killed. No matter what physical damage is inflicted it will survive and repair itself."

Bizarre — "a species that is does not die easily of natural causes and is hard to kill. If any of its principal parts are severed it will still live with the remaining parts."

Common — "a species that will die if it doesn't get enough nourishment or if it is severely damaged. If any of its principal parts are severed, it will surely die."

Physical Object

Counterintuitive — "an object that is completely invisible under any viewing conditions."

Bizarre — "an object that is difficult to see under normal lighting conditions even with the aid of a microscope."

Common — "an object that is easy to see under normal lighting conditions from within about 50 feet away."

Materials. All three versions of each of the 18 items were generated and written such that they were as similar as possible. Each of the three different versions of the story had six expectation-violating items, six bizarre items, and six common items. Similarly, for each ontological grouping (living

A crossing error led to one set of physical objects being under-represented, appearing in only two instead of three versions of the story, and another set being over-represented, appearing four times. This did not change the overall number of counterintuitive, bizarre, or common items that were presented, and did not alter the results in any detectable way.

things, physical objects, intentional agents), each level appeared twice in a given story. Each of these three story versions also had three different orders to control for any order effects. Consequently, in all there were nine different versions of the story with each item and level appearing the same number of times.

The stories were structured to ensure maximum control over complicated variables such as the role of objects in the narrative structure and amount of repeated exposure to a given concept. Though the story had a main character, a true beginning and a true ending, the appearance order of the test items was irrelevant for the narrative structure as was any particular item.

Participants. Eighteen college students participated in each of the three generations, two for each of the nine versions of the story, for a total of 54 participants ranging in age from 16 to 25, with a mean age of 18.8 years. Thirty-four were female.

Procedure. In the first generation, participants read their story once through "carefully" and then one more time through. After a delay of approximately two minutes (the time it took for each to move to a computer terminal and type in a story number, age, and sex, and receive instructions) participants typed out the story as best they could from memory. This generated two retellings of each of the nine story versions. Participants in the second generation then read both retellings for one of the nine original stories one time carefully. For example, one would read the two retellings of story version #1, another would read the two retellings of version #2, and so forth. Before reading, the experimenter told participants that they were reading two versions of the same story. The second generation participants were then asked to retell the two retellings they read as one story. Again, this produced two retellings of each of the nine stories. The procedure followed by Generation 2 was repeated for Generation 3.

Participants in Generations 2 and 3 read both retellings from the previous generation to maximize the chance for all information to be preserved. One problem with a serial reproduction design is that once information is omitted from a series, it is gone for good. One forgetful person at the beginning of the chain would permanently lose a concept. Another reason for cross-fertilizing the transmission process was to better

approximate what happens when stories are passed down in a real cultural setting. Rarely is information disseminated in a completely linear manner.

In this task, Boyer's theory leads to the prediction that assumption-violating items should be remembered and transmitted more successfully than common items. Bizarre items were included just to see if non-counterintuitive properties, if salient, would be transmitted just as well or better, as suggested by previous research.

Results and Discussion

Two hypothesis-blind, independent coders scored the produced stories for two things: (1) which of the original items (from the original story or the previous generation) were remembered and recorded in some identifiable form, and (2) whether the recorded items were described as counterintuitive, bizarre, or common.[5] With these two pieces of information, it was determined which items were best remembered in any form, and which item type was best represented by the end of transmission. Domains of items (agents, living things, and objects) were collapsed for these analyses.

Of the original items from the first stories, counterintuitive and bizarre items were remembered significantly more often than common items. By the time the third generation retold the stories, on average 5 of the original 18 items per story were left, 2.11 counterintuitive items ($SD = .96$), 1.89 bizarre items ($SD = 1.41$), and .89 common items ($SD = .96$). Paired t-tests comparing each type with each of the other two detected significant differences between both counterintuitive and common items, $t(17) = 4.65$, $p < .001$, and between bizarre and common items, $t(17) = 2.64$, $p = .017$. This pattern held across all three types of items (living things, intentional agents, and physical objects). So, just considering if an item was remembered at all, counterintuitive features do seem to provide some advantage over common features. However, this advantage might have nothing to do with violating intuitive assumptions, but might simply be because these features are more interesting. Bizarre items, which do not have counterintuitive features but are also unusual and interesting, showed the same advantage over common items.

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[5]Inter-rater agreement was 85.0%. Disagreements were resolved through discussion.

Considering *how* items were remembered provides more telling information. After three generations of retellings, along with many of the items being forgotten, many items were distorted. Some items that began as bizarre became common (12.5% of bizarres), and some common items became bizarre (22.2% of commons). But by far the largest type of shift was from bizarre to counterintuitive. While only 7.2% of counterintuitive items that were transmitted degraded into bizarre items, 37.5% of bizarre items became counterintuitive items after repeated retellings. Consequently, on average, participants in Generation 3 remembered 2.72 items *as* counterintuitive items ($SD = 1.49$), as compared with 1.39 as bizarre ($SD = 1.33$), and .89 as common ($SD = .96$). The differences between counterintuitive and bizarre, $t(17) = 5.62$, $p < .0001$, are significant. The difference between bizarre and common recall is not significant, $t(17) = 1.16$, $p = .261$. Again, this pattern holds across the three item types and for all three generations. Table 2 shows these results. Results of Generation 2 are not reported because they are redundant with Generations 1 and 3.

That common items were remembered so poorly relative to other items is particularly surprising given the reaction of some participants to these items. Since in normal discourse intuitive properties are assumed and not explicitly stated, some subjects reported that these items were particularly odd and memorable. In some instances of retelling these items,

Table 2

Experiment 2 results: Mean number of items recalled per subject as being a given type, by ontology

	Biological	Physical	Psychological	Total
Generation 1				
Counterintuitive	1.39	1.22	1.28	3.98
Bizarre	1.17	0.83	1.22	3.22
Common	0.72	0.78	0.78	2.28
Total	3.28	2.83	3.82	9.39
Generation 3				
Counterintuitive	0.56	1.39	0.78	2.72
Bizarre	0.33	0.50	0.56	1.29
Common	0.28	0.39	0.22	0.89
Total	1.17	2.28	1.56	5.00

participants tried to make the common property sound exciting or unusual. For example, a physical object that could be moved at speeds of 100 miles per hour were said to move at amazingly fast speed (like 100 miles per hour), even though almost any physical object can be moved at this speed.

In this task, concepts with minimal expectation-violating properties stood a better chance of surviving transmission than concepts that satisfied all intuitive assumptions. This facilitated transmission was due to two factors: counterintuitive concepts were simply more memorable, and unusual properties tended to be changed into counterintuitives.

Experiment 2 offered some evidence that expectation-violating concepts are better remembered and transmitted than merely bizarre concepts or mundane ones. However, Experiment 2 had some shortcomings. First, while fairly carefully controlled, the narrative used was artificial in style, using a setting (other world) commonly associated with counterintuitive concepts as found in science fiction, and only giving ontological information about objects (e.g., living thing) instead of basic level labels (e.g., dog). Second, Experiment 2 used written stimuli while traditionally, stories and cultural concepts are transmitted orally. Third, recall was only examined immediately following transmission, whereas in natural settings transmission of a concept may occur long after exposure to the concept. Finally, the style of transmission was only a modest approximation of how information is spread in a culture. Real world transmission involves actual face to

Table 3

Experiment 2 target items imbedded in the story

Counterintuitive Items	A dog composing a symphony
	A rose jumping
	Shoes sprouting roots
	A carrot that speaks
	An iridescent blue horse
	A snowflake that burns clothing
Control Items	A slimy feeling earthworm
	Crumpled newspaper blowing in the wind
	Brittle, fallen leaves
	A bird with bright red feathers
	An aromatic shrub
	A red picket fence

face interactions, hearing different versions from multiple speakers, and the effects of telling stories multiple times. Experiments 3 and 4 were attempts to extend the findings to these other contexts.

In Experiments 3 and 4, a group of adults in a single room served as a small, mock-village or cultural group. The experimenter told a subset of the group a story and then asked the subset to initiate a series of retellings within the greater group.

Experiment 3

Method

Participants. Thirteen male and ten female college students ranging in age from 18 to 20 ($M = 18.7$ years) from an introductory psychology class at a Midwestern American liberal arts college participated to fulfill part of their course requirements.

Materials. A story was composed by a student author about a boy and girl walking home from school. On the way home, they encounter twelve target items, six expectation-violating items and six control items. A list of ordinary objects including plants, animals, and inanimate objects was generated. Then a subset of these objects were selected randomly. Objects were randomly assigned to be either counterintuitive or control items with ontological category membership balanced across the two groups. That is, three of each item type were inanimate, two were animals, and one was a plant. Table 2 displays the twelve target items imbedded in the story. The complete text may be found in Appendix B.

Because the author constructed the story such that it sounded like a natural narrative rather than a formulaic listing of items, the protagonists (the boy and the girl) interacted with and reacted to the objects in different ways depending on the nature of the object. Consequently, not all items were mentioned the same number of times or interacted with the same number of times. To insure that this irregularity did not result in a bias for remembering the counterintuitives, two strategies were used. First, the author's narrative was modified slightly to make the number of mentions and interactions comparable. The six counterintuitive items were mentioned a total of 15 times (including pronouns) versus 14 times for the control items. Similarly, the children interact with the control items

10 times versus 7 times for the counterintuitive items. Additionally, post hoc linear regression analyses showed that neither the number of times an item was mentioned nor the number of times the children interacted with the items significantly predicted rate of item recall.

Procedure. The experimenter gathered participants in a single room and told them that they would be told a story that they should then tell to at least two other people. The experimenter placed no restriction on to whom the participants should choose to tell the story, but encouraged the participants to move about the room and tell anyone they liked. After giving these instructions, the experimenter extracted eight participants from the room and took them to an adjacent room. There, the experimenter told the eight participants the original story and then sent them back to the first room to retell the story. After all participants had been told the story, the experimenter asked them to each write their age, sex, and best account of the story on lined notebook paper. Then, without telling participants that they would be contacted again, the experimenter contacted students three months after initially participating and asked them to recall the story again.

Results

Two independent coders scored the stories produced by the participants for which of the original target items were recalled and if they were recalled accurately, i.e., having the original feature.[6] Paired t-tests were used to examine differences in recall rates between item type (control versus counterintuitive items). These results are illustrated in Figure 1.

Immediate recall. Examining simply which items were recalled at higher frequency regardless of which features were remembered along with the item, counterintuitive items were recalled significantly more often than control items, $t(22) = 7.36$, $p < .001$. Participants recalled counterintuitive items 71.1 percent of the time on average ($SD = 22.2$) compared with 43.5 percent ($SD = 24.5$) for control items. Five of the six most frequently remembered items were counterintuitive items.

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[6]For the stories produced immediately following transmission, raters agreed 96.4 percent of the time. For the stories produced after a three-month delay, raters agreed 92.2 percent of the time. Raters resolved disagreements through discussion.
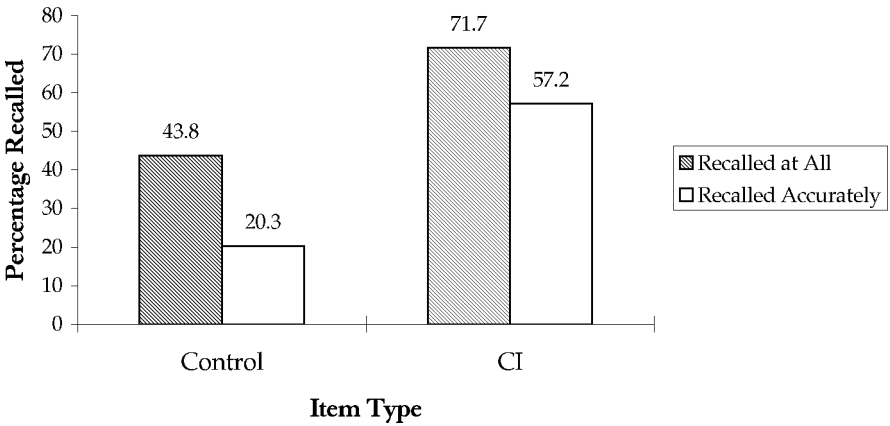
Figure 1. Experiment 3 results for immediate recall. Mean recall by coding criteria and item type. Differences between counterintuitive and control items are significant for both criteria.
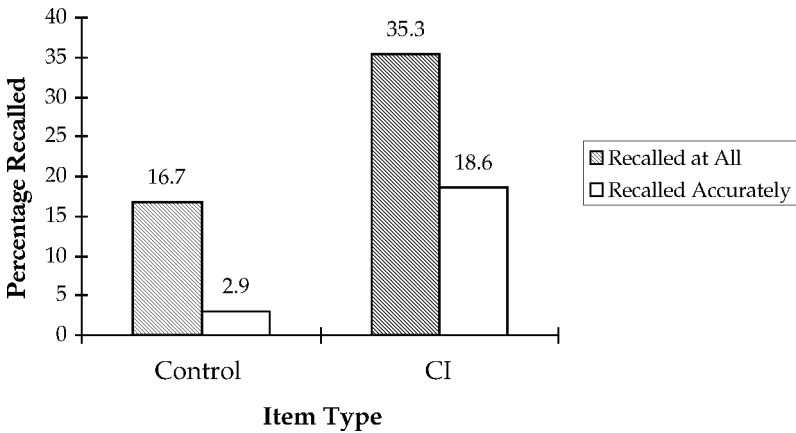

Figure 2. Experiment 3 results for three-month delayed recall. Mean recall by coding criteria and item type. Differences between counterintuitive and control items are significant for both criteria.

When using stricter criterion of accurate recall (i.e., recalling items with the same features as in the story), the same pattern emerged. Participants recalled counterintuitive items 57.2 percent of the time on average ($SD = 26.5$) compared with 21.0 percent ($SD = 20.2$) for control items, $t(22) = 7.11$, $p < .001$. The three most frequently accurately

recalled items were counterintuitive, whereas the four least frequently accurately recalled items were control items.

Three-month delayed recall. Of the 23 original participants, only 17 were successfully contacted three months later. As with stories produced immediately following transmission, participants recalled counterintuitive items more frequently than control items when considering if items were recalled at all, $t(16) = 3.38$, $p = .004$, and when considering whether items were recalled accurately, $t(16) = 2.89$, $p = .011$. On average, participants recalled 35.3 percent ($SD = 26.3$) of the counterintuitive items in some form and 18.6 percent ($SD = 26.3$) accurately. Of the control items, 16.7 percent ($SD = 20.4$) were remembered in some form on average, and 2.9 percent ($SD = 8.8$) of them accurately. Figure 2 illustrates these results.

Discussion

As in Experiment 2, participants remembered and transmitted counterintuitive items better than control items. Unlike Experiment 2, the vehicle story for the concepts was more similar to natural narratives in setting, style, and descriptions of the items. Similarly, the oral, conversational style of the transmission, allowing participants to tell the story to whomever they wanted, was also more naturalistic. Finally, the recall advantage of counterintuitive items after a three month delay suggests that the mnemonic advantage of these concepts may not be limited to immediate retellings.

Experiment 4

Whereas participants in Experiment 2 transmitted counterintuitive concepts more successfully than "bizarre" items, items were deemed "bizarre" a priori. Perhaps participants found counterintuitive items more bizarre than the "bizarre" items and remembered them better for this reason, not because of violations of expectations. Similarly, the transmission advantage of counterintuitive items in Experiment 3 could be because the control items appeared too mundane to be worthy of attention. Experiment 4 was an attempt to address these issues by replicating Experiment 3 with bizarre items replacing the control items, and asking subjects to rate the bizarreness or novelty of all the items for an independent measure of bizarreness.

Method

Participants. Eighteen female and nine male college students ranging in age from 17 to 19 years ($M = 18.3$) from an introductory psychology class at a Midwestern American liberal arts college, participated to fulfill part of their course requirements.

Materials and Procedure. The experimenter told participants the same story as in Experiment 3 with minor modifications. The control modifiers used in Experiment 3 were replaced with modifiers that would make the objects extremely unusual or bizarre without becoming counterintuitive or undermining category membership. For example, the crumpled newspaper from the original story became a bright pink newspaper — highly unusual for a newspaper, but still a newspaper. Other modifications include: a warm, fuzzy worm replaced a slimy-feeling worm, leaves as big as tables replaced brittle leaves, a bird swallowing nails replaced a bird with bright red feathers, a shrub that smells like laundry detergent replaced an aromatic shrub, and a rubber picket fence replaced a red picket fence. Consequently, the story contained six counterintuitive target items and six bizarre target items. Otherwise, the story and transmission process were identical to Experiment 3.

To examine more carefully if the previously demonstrated transmission advantage for counterintuitive items is another instance of the novelty effect often found in within-subjects designs (Waddill & McDaniel 1998), after writing the story following transmission, participants rated each of the twelve items for bizarreness or novelty. The experimenter gave each participant a sheet of ratings in which participants rated on a five point scale "have you ever seen or encountered" each item in (1) "real life" or (2) "in movies, books, or anywhere else (other than this experiment)." The scale ranged from 1 = "yes, many times" to 5 = "no way, never." The two ratings for each item were combined to yield a "novelty" rating.

Results and Discussion

Two independent coders scored the stories produced by the participants for which of the original target items were recalled and if they were recalled

accurately.[7] As in Experiment 3, paired t-tests were used to examine differences in recall rates between item type (bizarre versus counterintuitive items). These results are illustrated in Figure 3. As in previous experiments, counterintuitive items enjoyed a transmission advantage that appears independent of familiarity or novelty of the concepts.

Immediate recall. Examining simply which items were recalled at higher frequency regardless of which features were remembered along with the item, counterintuitive items were recalled significantly more often than bizarre items, $t(26) = 10.37$, $p < .001$. Participants recalled counterintuitive items 82.7 percent of the time on average ($SD = 12.6$) compared with 40.1 percent (SD = 17.5) for control items. Five of the six most frequently remembered items were counterintuitive items.

When using the stricter criterion of accurate recall (i.e., recalling items with the same features as in the story), the same pattern emerged. Participants recalled counterintuitive items 74.7 percent of the time on average ($SD = 15.6$) compared with 32.7 percent ($SD = 19.9$) for bizarre items, $t(26) = 11.01$, $p < .001$. Five of the six most frequently accurately recalled items were counterintuitive.

Interestingly, as in Experiment 2, some of the bizarre items transformed into counterintuitive items through transmission. The most common distortion of this kind was for the bright pink newspaper blown by the wind. Of the ten participants who remembered the newspaper, six recalled it as walking or running, not blowing in the wind. It is tempting to speculate that memory for the newspaper might have been even poorer if it had not been animated through retellings.

Three-month delayed recall. Twenty-one of the 27 original participants were successfully contacted and provided data. As with stories produced immediately following transmission, subjects recalled counterintuitive items more frequently than bizarre items when considering if items were recalled at all, $t(20) = 2.74$, $p = .013$, or recalled accurately, $t(20) = 2.87$, $p = .009$. On average, participants recalled 34.1 percent ($SD = 25.0$) of the counterintuitive items in some form and 23.0 percent ($SD = 21.4$)

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[7]For the stories produced immediately following transmission, raters agreed 96.0 percent of the time. For the stories produced after a three-month delay, raters agreed 95.2 percent of the time. Raters resolved disagreements through discussion.
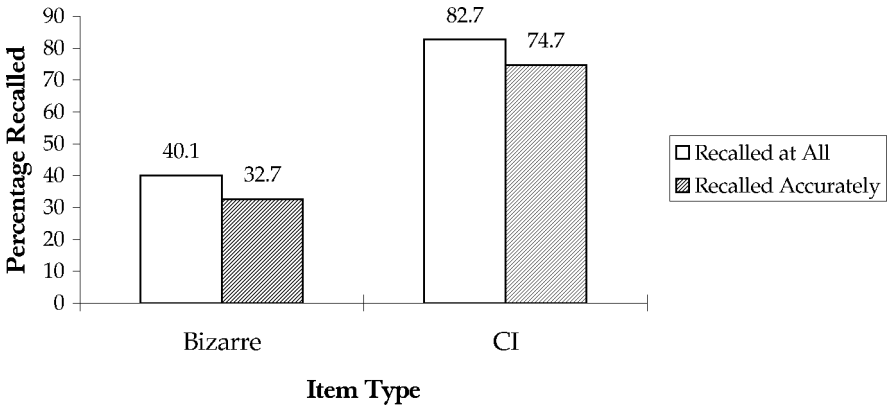
Figure 3. Experiment 4 results for immediate recall. Mean recall by coding criteria and item type. Differences between counterintuitive and bizarre items are significant for both criteria.
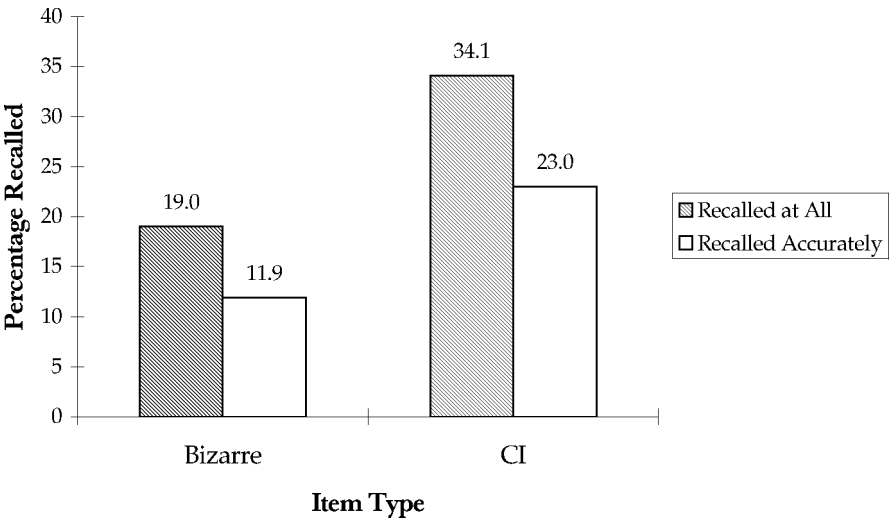

Figure 4. Experiment 4 results for three-month delayed recall. Mean recall by coding criteria and item type. Differences between counterintuitive and bizarre items are significant for both criteria.

of them accurately. In contrast, participants only recalled 19.0 percent ($SD = 15.2$) of the bizarre items on average, and 11.9 percent ($SD = 12.0$) of them accurately. These results appear in Figure 4.

Novelty ratings. As expected, participants rated both counterintuitive items and bizarre items as extremely unusual or novel. However, participants rated bizarre items as more novel than counterintuitive items and novelty did not predict recall. On a five-point scale, bizarre items had a mean novelty rating of 4.47 ($SD = .367$) with counterintuitive items rated 4.36 ($SD = .289$) on average. This difference was significant, $t(26) = 2.21$, $p = .036$, with bizarre items considered slightly more novel or unusual. Consequently, a multiple linear regression predicting item recall from novelty ratings and item type (counterintuitive versus bizarre) detected no recall advantage related to higher novelty ratings once item type was statistically controlled. However, the partial relationship between item type (controlling for novelty) was a significant predictor for both general and recall rate, $t(11) = 2.63$, $p = .027$, and for accurate recall, $t(11) = 2.92$, $p = .017$.

General Discussion

The four experiments presented above support Boyer's theory that counterintuitive concepts have transmission advantages that account for the commonness and ease of communicating many non-natural cultural concepts. In Experiment 1, participants recalled expectation-violating items from culturally unfamiliar folk stories better than more mundane items in the stories. In Experiment 2, participants in a modified serial reproduction task transmitted expectation-violating items in a written narrative more successfully than bizarre or common items. In Experiments 3 and 4, these findings were replicated with orally presented and transmitted stimuli, and found to persist even after three months. To sum, controlling for factors such as the role objects play in a story, the ecological relevance of the concepts, and motivational factors concerning the relaying of a concept, concepts with single expectation-violating features were more successfully transmitted than concepts that were entirely congruent with category-level expectations, even if they were highly unusual or bizarre. This transmission advantage for counterintuitive concepts may explain, in part, why such concepts are so prevalent across cultures and so readily spread.

The results converge with the findings of Boyer and Ramble's (forthcoming) cross-cultural studies in which participants more accurately recalled items violating category-level expectations than items meeting

expectations. Their research also demonstrated little difference between cultures in sensitivity to such violations.

The theory tested here does not claim that semantically- or script-incongruent concepts will be remembered better than congruent ones, but instead explores the pan-cultural mechanisms upon which scripts and schemas rely by testing the mnemonic advantage of concepts which contain violations of expectations at the category level (i.e., living things, physical objects, and intentional agents). Consequently, these findings do not challenge story comprehension theories that maintain that non-schematic or script-incongruent ideas, events, and concepts will not be well remembered but forgotten or distorted to fit schematic expectations (e.g., Rubin 1995), but involve a fundamentally different theory.

While the experiments presented do not directly address possible mnemonic advantages for concepts that evoke bizarre imagery (Einstein, McDaniel & Lackey 1989), they do suggest that some bizarre images might be remembered better than other images because they represent an expectation-violating concept. However, as suggested above, not all expectation-violating concepts stimulate bizarre imagery and not all bizarre images are expectation-violating concepts.

The most striking thing about these data is that some intuitive but unusual properties were transformed into expectation-violating properties (Experiments 2 and 4), suggesting that some expectation-violating properties might be easier to represent. How could that be? Perhaps counterintuitive features that are mere negations of intuitive assumptions are easier to "tag," and therefore keep track of, than complicated, common features. For example, it could be easier to remember that some living thing will never die than that some living thing will die after its blood-alcohol level reaches .4, provided its blood-sodium levels are less than .05. In the counterintuitive case, one need only put a negative tag on an intuitive assumption (that living things eventually die), but in the bizarre case, all of the conditions must be encoded.

Some support for this speculation can be found in Ward's (1994, 1995) work on "structured imagining." When adults were asked to draw and describe novel imaginary animals from a totally different world, it was found that they tended to structure the animals based on the intuitively assumed properties of the concept "animal." When participants did deviate

from these intuitions, the deviations were almost always simple negations of an intuitive assumption. In this way the intuitive properties of the governing category still structured the novel concept.

Another bit of supporting evidence comes from Experiment 1. In one story, "Woman Chooses Death," Old Man proposes that to decide whether or not humans will experience death, he will throw a buffalo chip into a river. If the chip floats, humans will die but come back to life after four days. What would happen if the chip sinks is never stated in the story. Several participants who retold this story remembered the bargain as being if the chip floats, people will live forever. This subtle distortion suggests that the simplified concept, "To live forever" is easier to represent than "to live for some time, die, and four days later come back to life." Note, however, that these may both be expectation-violating concepts.

If expectation-violating features facilitate transmission, why, then, are expectation-violating and "religious" concepts the minority of cultural concepts? Numerous other factors, such as frequency of concept exposure, attention paid to that exposure, motivation for communication, ease of concept reproduction, and conformism effects undoubtedly influence the production and transmission of concepts (Boyer & Ramble, forthcoming). For example, a village might have a concept of "ghost" that is reinforced every time something mysterious happens such as an illness, a missing chicken, or a freak storm, but the concept "water" as something good for drinking is reinforced many times daily. Although ecological factors cannot be completely controlled, holding factors such as frequency of exposure constant, it appears that expectation-violating concepts might possess some advantages.

Does this suggest that the more counterintuitive features a concept has, the better? No. Too many counterintuitive features would undermine the structure of the concept. Its relations to relevant causal theories would be disrupted. A cat that can never die, has wings, is made of steel, experiences time backwards, lives underwater, and speaks Russian, would no longer be much of a cat. Consequently, the causal schemata would no longer generate sensible intuitive expectations, and so there would be no counterintuitive properties, but a list of disconnected features. What Boyer proposes is a cognitive optimum: a balance between satisfying ontologically-driven intuitive expectations and violating enough of them to become

salient (Boyer 1995). Concepts that meet this balance may be termed minimally counterintuitive.

If it is true, as Boyer argues, that many religious concepts are minimally counterintuitive and thus enjoy facilitated transmission, the data presented above corroborate the arguments of several scholars applying insights of cognitive science to the study of religion. Each of these scholars has maintained that religious beliefs and practices are "natural" or "intuitive" in the sense that they primarily enlist ordinary cognitive resources. Lawson and McCauley have shown how religious rituals are undergirded by garden-variety action and agent representations (1990). Guthrie (1993) maintains that gods are explained by an overactive agent detection device that cares little if a postulated agent has some non-human qualities such as invisibility since being able to reason about unseen agents would have had great survival value in our evolutionary past. Similarly, Barrett and colleagues (Barrett, in press; Barrett & Keil 1996; Barrett, Richert & Driesenga, in press) have argued that concepts of religious agents, such as gods, are largely informed by intuitive assumptions governing all intentional agents, making these easy concepts to entertain and use in many contexts. Adding to these other cognitive perspectives on religious concepts, an explanation for how religious concepts might be so easily transmitted may build a cumulative, naturalistic explanation for much of religion in general.

The results presented here demonstrate the importance of intuitive conceptual structures in informing and constraining the spread of cultural materials that extend beyond mundane concepts or experiences. Many people know about ghosts, not because they have frequent interaction with them, or because knowledge about them is important for successful survival, but because they largely fit intuitive assumptions about agents while possessing a small number of expectation-violating features that make them interesting and memorable. Returning to the Chivo Man, he could have become such a widely known local character not because of any particular importance he holds in everyday life or because of any actual interaction with him. Rather, a part-animal, part-human creature violates one of our expectations for animals while maintaining rich inferential potential based on pan-cultural category-level knowledge.

Appendix A

One version of nine used in Experiment 2

I was sent as a diplomat to the planet Ralyks. Because the decision was very sudden and I didn't have a lot of time to research Ralyks, I decided to take a visit to Ralyks' equivalent of the Smithsonian — a large network of museums and zoos intended to provide a representative sampling of all of the different kinds of things of this world.

The first building I entered was a huge cross with four wings, devoted to the various types of beings that initiate action in this world. They all act and behave in ways that are motivated by internal states. They don't just respond to their environment, they act on in as well. In the first one, perhaps the most telling wing, was a fine collection of restaurants and gift shops. All of them were outrageously overpriced, so I went on to the rest of the building.

The next wing I went into was painted blue and contained exhibits devoted to the various types of beings that initiate action in this world. In the first room was a type of being of which all members normally are able to reproduce. Each member of the species has two biological parents.

The second room illustrated a being that will never die of natural causes and cannot be killed. No matter what physical damage is inflicted it will survive and repair itself. Rounding a corner, I came upon an exhibit concerned with a being that is aware of its own existence and usually conscious of what it is doing. It knows when it is thinking and knows when it is trying to do something.

To the south of this room was one containing a being about the size of a young human that is impossible to move by any means.

The next room had in it a being about the size of an adult human that weighs about 150 pounds.

In the last room of the wing was a being that is easy to see under normal lighting conditions from within about 150 meters away.

The next wing I went into was painted red and contained exhibits devoted to the various types of beings that initiate action in this world. In the first room was a being that can see of hear things no matter where they are. For example, it could make out the letters on a page in a book hundreds of miles away and the line of sight is completely obstructed.

The next exhibit featured a being that has no desires that motivate what it does. It never wants something, it just goes after things for no reason. It never wants to do things, it just does things randomly.

I continued through the dimly lit hall and came to an exhibit about a being that is able to pass through solid objects. Being the size of an adult human, it can pass directly through solid objects.

Adjacent to this room was a display dedicated to a kind of being that requires nourishment and external sources of energy in order to survive. It consumes and metabolizes caloric materials to sustain itself.

After going up a few steps, I came to a room that displayed a being that can move quickly. It can moved at speeds of about 20 miles per hour.

The next room I came to featured a being that can be completely in more than one place at a time. All of it can be in two or all four different corners of the room at the same time.

The next wing I went into was painted yellow and contained exhibits devoted to the various types of beings that initiate action in this world. The first exhibit I came to was about a being that never uses beliefs to guide its actions. For example, if it wants a banana, and it believes that a banana is in a box in the corner of the room, it will search randomly anyway as if it doesn't know the banana is there.

Then next exhibit concerned a being that can remember an unlimited number of events or pieces of information. For example, it could tell you in precise detail, everything it had witnessed in the past, and if you read it a list of 10 billion words, it would remember them all flawlessly.

The third exhibit featured a being that can pay attention to any number things all at the same time. For example, if ten people or ten billion people were talking to it at the same time, it would be able to keep track of what all of them were saying.

Near the end of the hall was another room featuring a being that is chiefly comprised of carbon-based molecules.

At the end of the hall were two more exhibits. One was a room devoted to a type of being that gives birth to and raises offspring that are the same type of being. Parents and offspring are always the similar.

The final exhibit of this wing featured a being that grows and changes most of its life cycle. At birth it must grow considerably to reach maturity; and after reaching maturity, it then changes as it deteriorates.

I left the building and went to my new office to ponder all of the things that can be found on Ralyks.

Appendix B

Story used in Experiment 3

A girl and a boy, sister and brother, were walking home from school on an ordinary day in an ordinary town. As they were walking towards home, they came upon a dog belonging to one of their friends. The dog crouched on the front lawn as it composed a symphony.

Since the dog was completely absorbed in its work, the two siblings continued on their way, chatting about what they had learned in school that day, until a beautiful rose jumped right in front of their path.

The children knew that they must be getting home, or else their mother would begin to worry, so they slipped away from the rose. They had hardly made any progress in their journey, when they noticed an earthworm crossing the sidewalk. The girl picked it up and felt its slimy texture and the squirm of its movement. She placed it on the grass on the other side of the pavement and they continued on their way.

As they were walking, the boy's shoes sprouted roots which broke up the pavement below and impaired his movement. He had had this trouble with these shoes several times before and always carried a pocket knife in order to cut the roots.

While the boy was engaged in the process of uprooting himself, a crumpled piece of newspaper blew past the girl in the cool breeze, brushing past her leg.

The children continued on their way. The leaves, which had fallen from the trees a while ago, were brittle and crackled under their feet. The children swished their way through the numerous leaves. The boy stopped to gather them in his arms and throw them at his sister.

They soon became hungry and so the boy reached into his backpack to retrieve a bag of carrots which he had not eaten during his lunch. She was just about to take a bite of one of the carrots when it screamed, "Stop!" The children then decided that perhaps they had better not eat any more carrots.

The children continued on their way until the girl paused to notice a bright red bird perched on the branch of a nearby tree. She explained to

her brother that the red feathers of the bird signified that it was male. The boy moved towards the bird, but it sensed his approach and quickly flew away.

The boy's behavior angered the sister, and so she ran ahead of him. She crossed the road and walked along a rolling field, her brother trailing behind her. Soon a horse ran along the edge of the field to where the boy was standing. He called to his sister, and forgetting her anger, she ran to see what he wanted to show her. The horse was a dazzling iridescent, almost transparent blue. The had seen this horse galloping across the field many times before, but this was the first time that they had been able to examine it up close.

As the children stood gazing at the animal, they noticed a beautiful and aromatic shrub nearby. It had a very fragrant smell that reminded them of their garden at home.

The sky had become a little darker since they had left school and soon a few snowflakes fell from the sky. The boy caught one of the sleeve of his jacket. It burned a hole in his jacket.

The air had turned cold, but the children were almost home. The soon caught sight of the brown picket fence in their very own front yard. They ran towards it and easily swung upon the gate of the fence. Their mother was inside and greeted them with hot chocolate and cookies while the children told her about their day.

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